SMALL SCALE WIND TURBINE (SYNCHRONOUS GENERATOR)

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"I hereby acknowledge that the scope and quality of this thesis is qualified for the award of the Bachelor Degree of Electrical Engineering (Power System)"

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Special dedicated to my parent, siblings, lecturer, friends and anybody were involved in this project.

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May Allah reward His peace and blessings to all of you, and may this work brings benefit to the mankind.

ABSTRACT

Small wind-powered electricity generation system, providing regulated AC electric power from wind energy to a power system grid, has a wind turbine that produces less than 10kW of peak electric power in a permanent magnet generator that produces generator power with a frequency that varies with the wind speed. The wind turbine utilizes a cross-wind type rotor having a power coefficient that varies with the operating tip speed ratio and has an optimal tip speed ratio where the power coefficient is maximum. A power converter, for converting generator power to regulated electric power by applying a controlled load to the generator controls operation of the wind turbine rotor such that the operating tip speed ratio is greater than the optimal tip speed ratio in a low wind speed region, is approximately equal to the optimal tip speed ratio in a medium wind speed region, and is greater than the optimal tip speed ratio in a high wind speed region. Boost converter used to boost up the output from the generator. However, wind turbine modeling should be done with more accurate to get the best value and have good efficiency.

ABSTRAK

Turbin angin kecil menjana sistem kuasa elektrik yang melaraskan kuasa elektrik ulang-alik dari tenaga angin kepada sistem grid kuasa, mempunyai turbin angin yang menghasilkan kurang dari 10kW puncak kuasa electrik di dalam penjana magnet kekal yang menjana kuasa dengan frekuensi yang berubah-ubah mengikut kelajuan angin. Turbin angin menggunakan rotor dari jenis pemancung angin untuk mendapatkan pekali kuasa yang berubah-ubah dengan nisbah kelajuan operasi untuk memberikan nisbah kelajuan yang optima pada pekali kuasa di tahap maksimum.Pengubahsuai kuasa digunakan untuk mengubahsuai kuasa dari penjana kepada kuasa elektrik yang selaras dengan menggunakan beban boleh kawal di kawalan operasi penjana di turbin angin apabila nisbah kelajuan operasi lebih besar dari nisbah kelajuan optima dalam kawasan kelajuan angin yang rendah, iaitu hampir sama dengan nisbah kelajuan optima dalam kawasan kelajuan angin sederhana dan lebih besar dari nisbah kelajuan optima di dalam kawasan kelajuan angin yang tinggi. Pengubahsuai injak naik digunakan untuk menginjak naik keluaran dari penjana. Namun, pemodelan turbin angin perlu dilakukan dengan lebih terperinci untuk mendapatkan nilai keluaran yang terbaik dan mempunyai kecekapan yang tinggi.

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LIST OF SYMBOLS

s	-	Second
V	-	Voltage
I	-	Current
P	-	Power
kW	-	kilowatt
m	-	meter
ft	-	feet
kV	-	kilovolt
MW	-	megawatt
SO_2	-	sulfur dioxide
NOx	-	Nitrous Oxide
Hg	-	mercury
ρ	-	air dnsity
A	-	Area swept by rotor
V^3	-	wind speed
H	-	height
m.p.h	-	mile per hour
km/h	-	kilometer per hour
Ω	-	ohm
F	-	farad
Hz	-	hertz
GDN	-	ground

LIST OF ABBREVIATIONS

AC	-	Alternating current
DC	-	Direct current
PVC	-	Polyvinyl chloride
B.C	-	Before Century
PIC	-	Programmable Interface Controller
HAWT	-	Horizontal Axis Wind Turbine
VAWT	-	Vertical Axis Wind Turbine
CCM	-	Continuous Current Mode
MOSFET	-	metal–oxide–semiconductor field-effect transistor

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CHAPTER 1

INTRODUCTION

1.1 Background

Wind power is generated by moving air. As the sun heats the land, the air above also warms and rises. Cold air then replaces the rising air. This creates the winds that we feel most days of the year. The diagram below shows how this 'system' works. Air tends to warm at a faster rate over land because the land retains its heat. Over the sea the air warms more slowly as heat by the sun is slowly cooled by the cold water. If you visit the seaside or coastal area you will probably find that the weather is more breezy or windy than inland. This is because the warm air rises over the land and cold air over the sea replaces it.

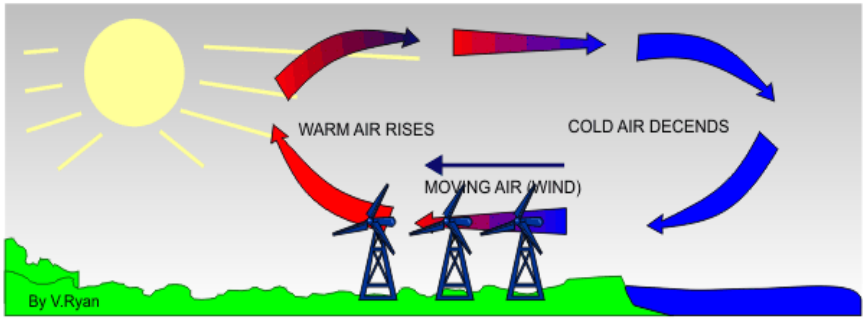

Figure 1.0: How wind turbine works

In Malaysia, especially at East Coast, have big potential to build wind power station. Since that there have enough wind moving for wind turbine. We can use the wind turbine at sea because we don't have enough space on land.

Nowadays, we try to find any alternative energy which is safe, friendly, renewal and useful in our life. Wind is one of the solutions which if we use it wisely wind will be our alternative energy support for our life.

Large wind turbine technology is already one of the larger future energy supplies and small wind turbines have a big potential. What is needed for a common use of wind are turbines that meet a specification that is flexible enough for general application and be possible to mount almost everywhere and plug-in to the grid. Wind turbines on the market are often larger, mounted on high towers and need plenty of space around them for safety and efficiency. The only way is therefore to specify flexible wind turbines which need a small space, cheap, low risk to install and high efficiency.

1.2 Objective of Project

The objective of this project is to;

i. To build a small scale wind turbine which produce 15Vac
ii. To understand the concept of designing a synchronous generator
iii. To built an additional boost converter circuit to amplified the result to 30Vdc

1.3 Scope of Project

In this project, I want to build a small scale wind turbine. There are the specifications of this wind turbine.

Voltage produce : 15 volts VAC
Type of current : Alternating Current (AC)
Generator : Synchronous generator
Application : Small appliances
Circuit : Boost converter
(double value from input about 30 Vdc)

1.4 Summary of Project

Implementation and works of the project are summarized into Figure 1.1 and Figure 1.2 below. Gantt charts as shown in Figure 1.3 and Figure 1.4 show the detail of works progress of the project that has been implemented in the first and second semester.

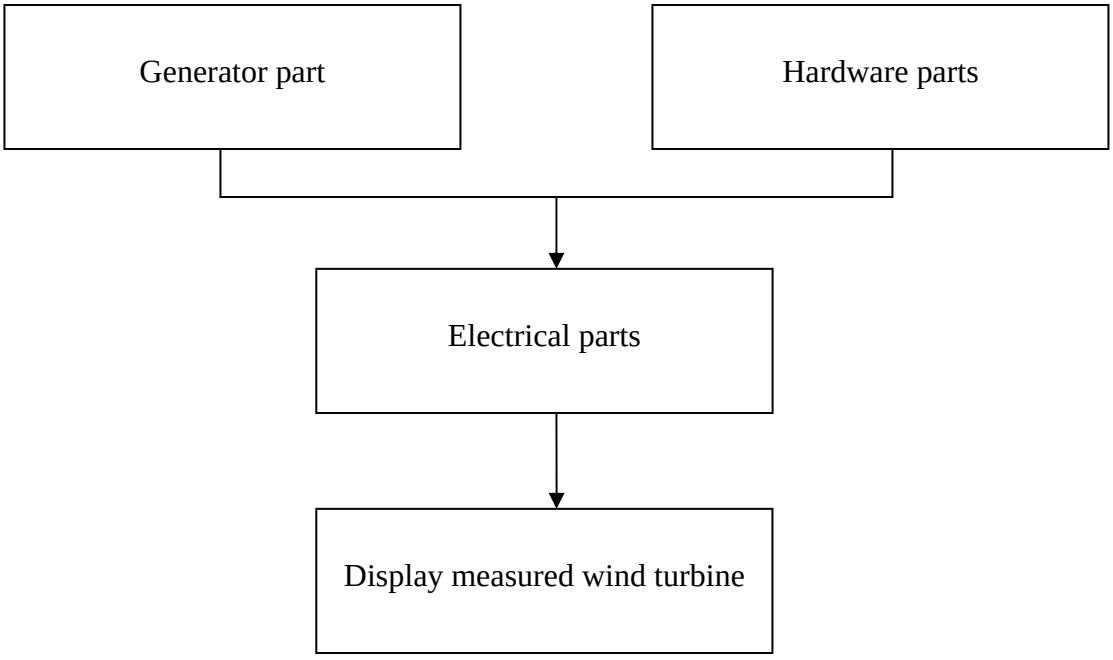

Figure 1.1: Block diagram

Description:

Generator part had been customize and modified from the car spare part components and bicycle's dynamo. By the first move on this project, the experiment about how to fabricate a synchronous generator had been done at Tasek Kasturi Company at Indera Mahkota Industrial Park. About 4 of bicycle's dynamo had been used to study the generator mechanism. During the experimental period, several sizes of

magnetic coil are used to rewinding the stator to see the value changes when the size of coil is vary. Then the number of turns also had been manipulated.

However during that period, another customize generator by using car's spare parts had been built. By using the alternator part, it had been modified into another generator. So in this project there have 2 prototypes that are built as comparison project. The first prototype is modified of dynamo and second prototype is modified of car alternator.

Description:

Hardware parts including the rotor blades, stand and tail. Rotor blades are made from PVC conduit pipe. There are 3 of blades is about 1 feet long each. The blades had been patterned with aerodynamic type that useful to cut off the wind and make them easy to rotate. The PVC type had been chosen because it was light weight and has strength.

The stand used to support the wind turbine while operate. It is portable stand that easy to move the prototype but in the real wind turbine, the stand must be fixing and has strong foundation to the ground to make sure it safe from strong wind. Then, the tail will direct according to the wind direction.

Description:

Electrical parts consist of power supply circuit, voltage regulator circuit, boost converter and all of this circuit only an additional circuit that only to double the wind turbine value about 30Vdc. This circuit also implements PIC circuit that used for control circuit. However this circuit can be upgraded directly to the appliances.

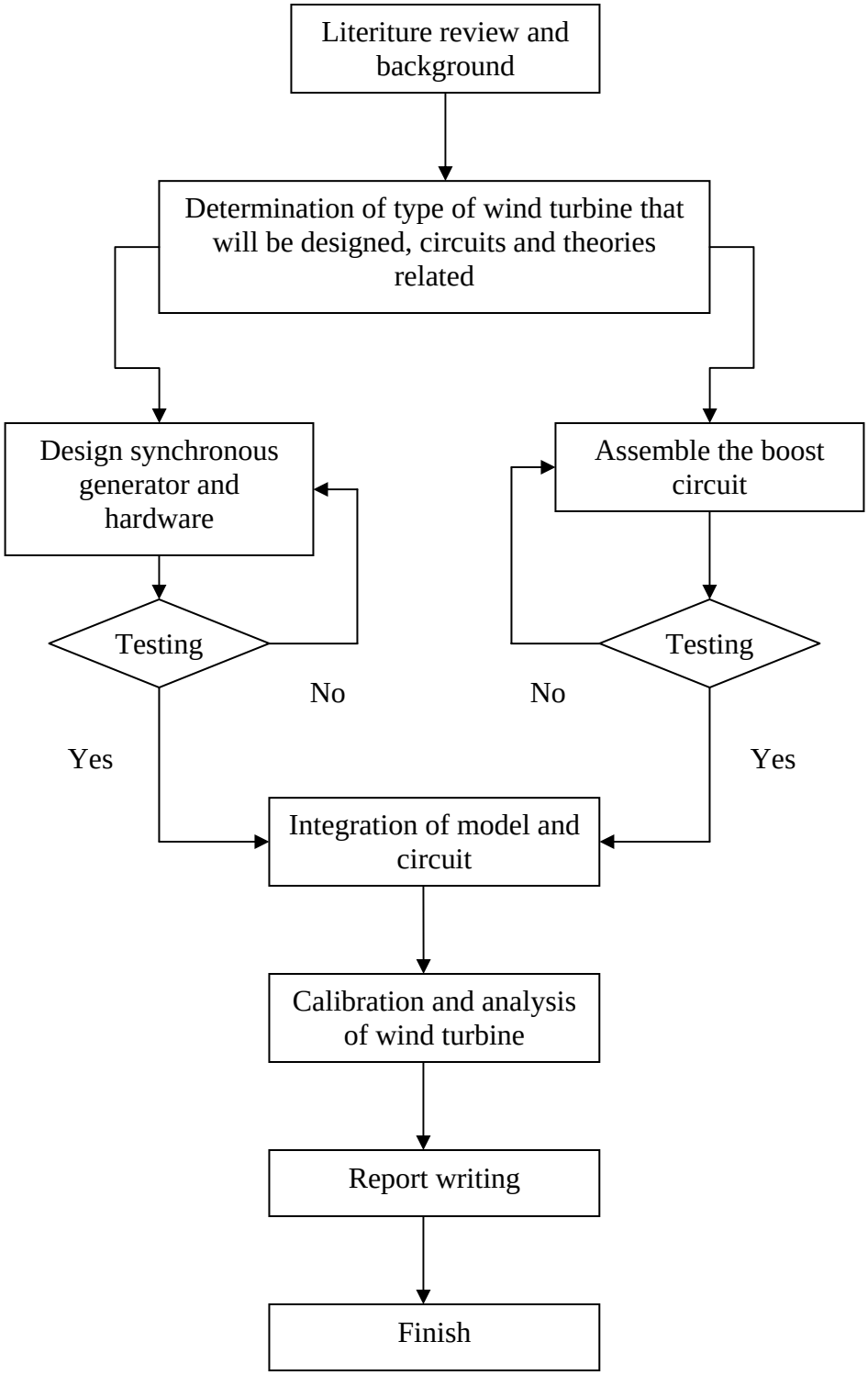

Figure 1.2: Flow of development

Description:

Literature review and research on theories related to the projects begin after the title of project was decided. These involve theories of numerous of wind turbine by obtaining most of the information from the internet and a few reference book. Small scale wind turbine was chosen to be developed in this project because it was relevant based on size and cost involved.

The project is divided into two parts; the modeling and circuit. The modeling part involves developing a synchronous generator, rotor blades, stand and tail. They had been testing to get the best model and it can be redoing if the model are not suitable for the project.

For the circuit part, boost converter had been fabricating based on calculation to get the output about double from the input voltage. It also includes power supply circuit and voltage regulator circuit since that output from wind turbine should be AC voltage. Then, this circuit had been tested to make sure that it will operate properly. All this circuit was doing by stage to avoid complicated during troubleshoot the error.

The integration of both the model and circuit will be done when both parts are ready.

Calibration process and analysis both are important to make sure the output are as expected. All the results and will be analyze for any changes that are needed. The value of output will be displayed on multimeter and oscilloscope.

After the entire task was done, report writing had been writing based on overall project related. Its was considered finish when the project had been succeed to achieved objective and all the information and data will be implement into a thesis.

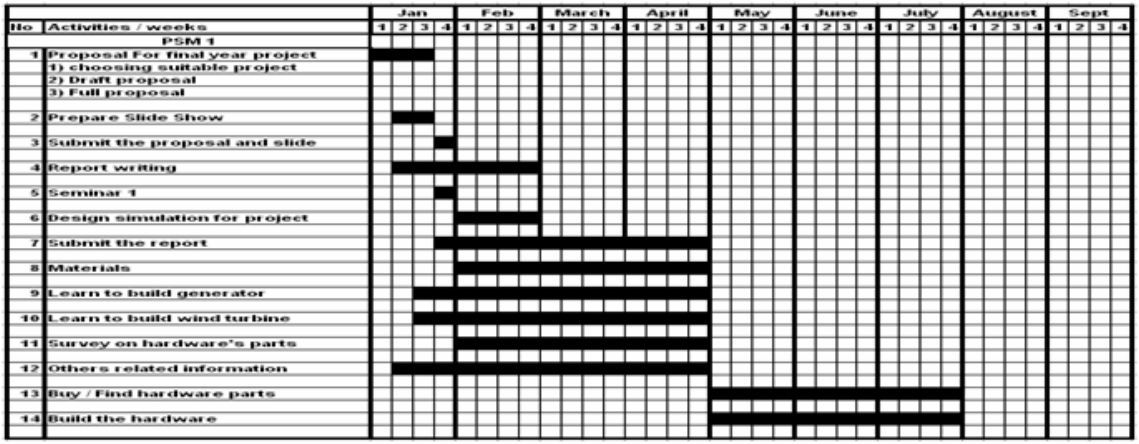

Figure 1.3: Gantt chart of the project schedule for semester 1

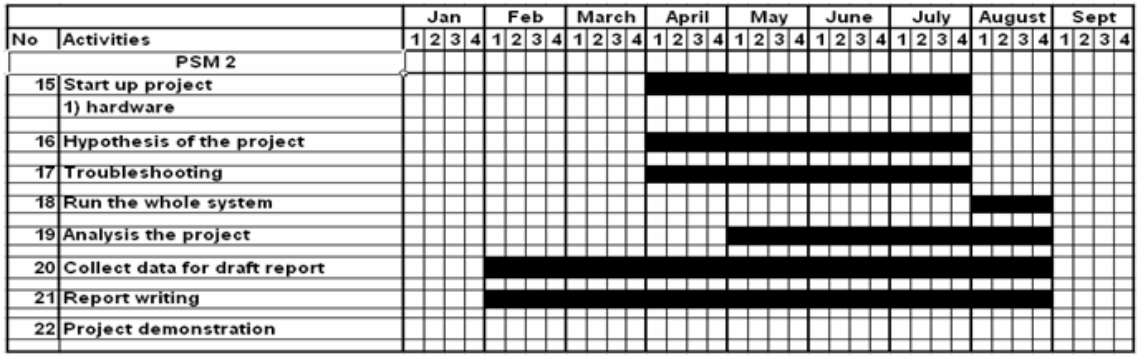

Figure 1.4: Gantt chart of the project schedule for semester 2

CHAPTER 2

THEORY AND LITERITURE REVIEW

2.1 Introduction

This chapter includes the study of wind turbine and its system. It also touches on microcontroller and other relevant hardware used in this project.

2.2 Wind Turbine

Rotating machine which converts the kinetic energy in wind into mechanical energy is called wind turbine. The developments of wind turbine start since 200 B.C which in Persia but until 250 A.D the usage of wind turbine had been introduced by Roman Empire. In 7^{th} century, the first vertical axle windmills had been developing at Sistan, Afghanistan. These windmills had long vertical drive shafts with rectangle shaped blades. It was made of six to twelve sails covered in reed matting or cloth material. It was used to grind corn and draw up water and was used in the grist milling and sugarcane industries.

In 14th century, the same type of windmill had been developing that use to drain areas of the Rhine River delta at Dutch, Denmark. Then in 1887, the first known electricity generating windmill operated was a battery charging machine installed by James Blyth at Scotland, United Kingdom. These technologies still grown when Charles F Brush develop the first windmill for electricity production at United States Cleveland, Ohio in 1888.After that about 2500 windmills for mechanical loads such as pumps and mills, producing an estimated combined peak power of about 30 MW at Dutch, Denmark in 1900.

Wind turbine technologies still grown up until 1908 at United States. There have 72 wind-driven electric generators from 5 kW to 25 kW. The largest machines were on 24 m (79 ft) towers with four-bladed 23 m (75 ft) diameter rotors. Around the time of World War I, American windmill makers were producing 100,000 farm windmills each year, most for water-pumping.

In 1930, the Windmills for electricity were common on farms, mostly in the United States where distribution systems had not yet been installed. In this period, high-tensile steel was cheap, and windmills were placed a top prefabricated open steel lattice towers.

Yalta, USSR in 1931 had made a forerunner of modern horizontal-axis wind generators was in service. This was a 100 kW generator on a 30 m (100 ft) tower, connected to the local 6.3 kV distribution system. It was reported to have an annual capacity factor of 32 percent, not much different from current wind machines.

However in 1954, the first utility grid-connected wind turbine operated was built by the John Brown Company at Orkney Islands, United Kingdom. It had an 18 meters diameter, three-bladed rotor and a rated output of 100 kW.

From 1955 until nowadays, every country want to used these technologies as alternative and renewal energy. More developments and research have been done to use wind turbine as renewal energy that have more advantages for natural. There have 3 level of range for the wind turbine. They are large scale for 500 kW until 5 MW, medium scale between 10 kW until 500 kW and the small scale is below than 10 kW.

Figure 2.1: Wind turbines near Aalborg, Denmark. For scale, a normally-sized doorway can be seen at the base of the pylon.

Figure 2.2: The world's first megawatt wind turbine at Castleton, Vermont

2.3 Why we use wind turbine?

We use wind turbine energy because wind for now is the renewable energy resource and technology of choice. It was a “free” resource and naturally. Also its a “clean” resource due to replacement of a “dirty” energy source (coal) and no emissions associated with its use. Wind turbine can be utilized on underutilized land or on lands currently in commodity crop production which is can be “harvest” on the surface and “harvest” above the surface. Then it will primarily be used for electricity generation for immediate end-use or as a “driver” for hydrogen production.

As we are know basically energy use in power plants accounts for 67% of air emissions of Sulfur Dioxide (SO_2), the primary cause of acid rain. SO_2 causes acidification of lakes and damages forests and other habitats. Then 25% of Nitrous Oxide (NOx), which causes smog and respiratory ailments. Also 33% of Hg (mercury), a persistent, bio-accumulative toxin which increases in concentration as it moves up the food chain which is example from fish to birds, causing serious deformities and nerve disorders.

Wind turbine one of the best choose that we have because it was no air emissions such as Sulfur Dioxide (SO_2), Nitrous Oxide (NOx), or Mercury Emissions. Also don’t have Greenhouse Gas Emissions. Then it no need for fuel to mine, transport, or store for the source. Its also don’t need any equipment like cooling water that we always use at fuel engine and nuclear reactor. There are never making pollution for example water pollution that always produces by mine activity. After all there is no waste when used wind turbine.

According to the Wind Resources in the United States, wind resources are characterized by wind-power density classes, ranging from class 1 (the lowest) to class 7 (the highest). However a good wind resources are (class 3 and above) which have an average annual wind speed of at least 13 miles per hour, that are found along the east